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Infectious Disease and Imperfections of Self-Image

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Abstract

Infectious disease is an ever-present threat in daily life. Recent literature indicates that people manage this threat with a suite of antipathogenic psychological and behavioral defense mechanisms, which motivate the avoidance of people and objects bearing cues to pathogen risk. Here, we demonstrate that self-image is also impacted by these mechanisms. In seven studies, pathogen cues led individuals chronically averse to germs to express greater concern about their own physical appearance. Correspondingly, these people exhibited behavioral intentions and decisions intended to conceal or improve their appearance, such as purchasing facial products, taking pharmaceuticals, and undergoing cosmetic surgery. This work opens a new area of investigation for infectious-disease psychology research and highlights the central role played by physical appearance in pathogen-related cognition.

Keywords

evolutionary psychology, physical appearance, infectious disease, behavioral immune system, self-evaluation, open data, open materials, preregistered

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None of us are perfect, even in our own minds—sometimes especially in our own minds. People suffer the slings and arrows of their insecurities when they focus attention, effort, and resources on self-perceived imperfections. These self-perceptions can apply to many attributes, from appearance to intelligence to social standing. Given the socially comparative nature of how we commonly evaluate such attributes, the unfortunate reality is that we can always view ourselves as needing to "do better."

A number of psychological theories describe mental processes that negatively impact self-evaluation. Here, we focus on a type of problem not previously linked to self-image, but one that has recurred across history and culture—the threat of infectious disease. Management of infectious disease is one of the most fundamental problems humans have confronted over their evolutionary history (Ackerman, Huang, & Bargh, 2012). Even in contemporary society, the annual mortality rate from infectious diseases outpaces the annual mortality rate from all 20th-century wars combined (Pirages, 2005). The physiological immune system is adapted to manage invading germs, but it is metabolically costly and effective only after infection. Recent research has explored complementary psychological mechanisms that mitigate contact with pathogen carriers, and hence, infection. Work on this behavioral immune system (BIS; Ackerman, Hill, & Murray, 2017; Murray & Schaller, 2016; Schaller & Park, 2011) reveals that pathogen cues elicit an array of avoidance-relevant reactions to external stimuli, including attention, movements, preferences, and prejudicial attitudes toward people and other potential pathogen carriers (e.g., Ackerman et al., 2009; Faulkner, Schaller, Park, & Duncan, 2004; Huang, Sedlovskaya, Ackerman, & Bargh, 2011; Lee & Zietsch, 2011; Mortensen, Becker, Ackerman, Neuberg, &

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Kenrick, 2010; Murray, Jones, & Schaller, 2013; White, Kenrick, & Neuberg, 2013).

We suggest that responses to pathogens are not solely focused on the outside world, however. An effective BIS should sensitize people to both external pathogen threats as well as to self-relevant vulnerabilities. The current investigation considered how pathogen concerns can focus people on specific aspects of their self-image that may represent potential vulnerabilities and motivate decisions to address these perceived vulnerabilities. By examining self-directed evaluations and decisions, this research expands our understanding of how infectious disease impacts our psychology and highlights a consequence with relevance for stigmatization and mental health.

The Behavioral Immune-Appearance Connection

If pathogen concerns do influence self-directed processing, which aspects are likely to be emphasized? Given that infectious diseases compromise bodily processes, we predict that BIS-driven responses will be particularly tied to concerns about the body. Our ancestors relied on sensory cues to index infection, just as we do now (Ryan, Oaten, Stevenson, & Case, 2012), and the most accessible cues likely involved physical appearance features. Infection can produce both temporary (e.g., eye discoloration) and lasting (e.g., scarring) deviations from normal appearance (Kurzban & Leary, 2001). Because these deviations are easily observed, appearance flaws serve as inputs for psychological mechanisms specialized in tracking and responding to infectious-disease threats.

This notion is consistent with interpersonal evidence showing that BIS activity (here defined as responses inclusive of both situational cues and chronic sensitivities) is associated with strongly negative reactions to people bearing certain physical features. Because the BIS uses liberal criteria for identifying pathogens (Haselton & Nettle, 2006; Nesse, 2005), even innocuous physical abnormalities can produce suspicion, disgust, and ostracism (Goffman, 1963; Kurzban & Leary, 2001; Murray & Schaller, 2016; Park, Faulkner, & Schaller, 2003). For example, individuals experimentally primed with pathogen cues allocate greater visual attention to faces bearing noncontagious disfigurements (e.g., port-wine stains, strabismal eyes; Ackerman et al., 2009). Further, chronic and situational germ concerns increase expression of negative attitudes toward obese (Fisher, Fincher, Hahn, DeBruine, & Jones, 2013; Lund & Miller, 2014) and unattractive (Park, van Leeuwen, & Stephen, 2012) individuals, and they heighten voting preference for physically attractive leaders (White et al., 2013). Trait pathogen disgust also predicts decreased preference for mates with sex-divergent or abnormal visual cues (Jones et al., 2013; Lee, Brooks, Potter, & Zietsch, 2015; Little, DeBruine, & Jones, 2011). Finally, higher ecological pathogen prevalence increases the value people place on romantic-partner attractiveness (Gangestad & Buss, 1993), potentially because physical attractiveness is indicative of developmental resistance to parasites (Thornhill & Gangestad, 1993).

The burgeoning BIS literature on interpersonal perception has important implications for self-evaluation, and evaluation of one's appearance in particular. Indeed, infection-induced appearance changes can be extremely anxiety inducing (Ginsburg, 1996). Behavioral immune activity might increase concerns about physical appearance for at least three reasons. First, the physical changes associated with infection may signal poor bodily health and thus promote hygienic behaviors that result in improved appearance. Second, people may carefully monitor their appearance because of the potential for others motivated by pathogen avoidance to stigmatize and ostracize physically abnormal people (Murray & Schaller, 2016). Consider the acne-related anxieties expressed by many teenagers. Much of the horror over a pimple breakout stems from fear of embarrassment and rejection by peers and potential romantic partners (and perhaps less so by health worries). Finally, a healthy appearance may facilitate mating success (Tybur & Gangestad, 2011). Given that romantically minded individuals place increased importance on physical attractiveness when pathogens are especially problematic (Gangestad & Buss, 1993), pathogen threat might trigger a focus on, and attempts to improve, one's mate value in the service of bettering romantic outcomes. Together, these possibilities suggest that BIS activity may motivate a wary eye toward the self just as it promotes apprehension toward others.

Current Research

To test the proposed connection between BIS activity and appearance, we conducted seven studies that examined the impact of chronic and situational pathogen sensitivities on self-evaluation and its consequents. These studies used multiple means of manipulating or measuring pathogen threat and examined both preferences and decisions targeting improvement of physical appearance while also addressing motivations to improve other bodily factors, such as physical fitness and hygiene. In all studies, chronic pathogen concerns were measured using the Perceived Vulnerability to Disease (PVD) scale (Duncan, Schaller, & Park, 2009), as individuals with higher perceived vulnerability display stronger BIS responses (Murray & Schaller, 2016),

particularly vulnerabilities associated with the Germ Aversion subscale (PVD_{GA}; Duncan et al., 2009; Faulkner et al., 2004; Huang et al., 2011; Murray et al., 2013; Park et al., 2003; Tybur, Frankenhuis, & Pollet, 2014), which we focus on here (see the Supplemental Material available online for results of the Perceived Infectability subscale, which produced inconsistent and largely null effects).

Altogether, this work expands our understanding of how behavioral immune responses impact human psychology by demonstrating that infectious-disease concerns (a) amplify specific kinds of self-relevant concerns (not merely reactions to the external world), (b) motivate corrective actions to address these concerns (not merely avoidance behaviors), and (c) produce changes that reflect appearance-related concerns.

Pilot Study

The BIS-appearance connection was initially inspired by an exploratory pilot study assessing whether cues to infectious disease produce changes in different domains of self-perception. After exposure to a pathogen threat or control prime, 178 participants reported their willingness to take pharmaceuticals that would alter either physical or nonphysical self-relevant characteristics (full methods and analyses are reported in the Supplemental Material). The physical characteristics included both appearance-relevant and fitness-relevant items. Initially, we considered that infectious-disease cues could motivate desire for both appearance and fitness traits, and we also made no specific predictions about whether the pathogen-threat manipulation would be moderated by chronic perceived disease vulnerability (researchers report both types of effects in different studies; Tybur et al., 2014). The results revealed only a Prime × PVD_{GA} interaction on a physical trait composite, $b = 0.64$, 95% confidence interval (CI) = [0.024, 1.247], $t(174) = 2.05$, $p = .04$, semipartial r^2 (sr^2) = .023, and no effects on a nonphysical trait composite, ps > .21. Simple-effects tests (we used the MODPROBE tool for all such tests; Hayes & Matthes, 2009) indicated that, for participants cued with pathogens, higher levels of germ aversion were associated with a stronger preference to improve one's physical traits, $b = 0.42$, 95% CI = [0.040, 0.807], $t(174) = 2.18$, $p = .03$, but this was not the case for participants in the control condition (the pattern for the effect ran in the opposite direction), $b = -0.21$, $p = .38$. Simple effects of pathogen-cue condition within levels of germ aversion were not significant, ps > .11. We drew on this first piece of evidence that BIS activity alters self-perceptions related to physical traits when situational cues to pathogen threat are present. Given that much evidence indicates that the threat of infection is associated with greater preference for physical attractiveness in other people (e.g., Gangestad & Buss, 1993; Jones et al., 2013; Park et al., 2012; White et al., 2013), we sought to test whether situational and chronic pathogen threats would specifically affect motivations to monitor and maintain one's own physical appearance.

To determine sufficiently powered sample sizes in the following studies, we reviewed effect sizes of several previous tests of experimentally manipulated pathogen cues on responses to appearance-relevant stimuli (Ackerman et al., 2009; Miller & Maner, 2012; White et al., 2013). We observed an average d of 0.65. To compensate for potential effect-size inflation, we estimated a d of 0.45, which is closer to effect sizes obtained by field-wide meta-analyses (Richard, Bond, & Stokes-Zoota, 2003). This suggested that a sample size of 158 would be needed to detect an effect with 80% power. We did not make any predictions for effects of participant sex, and thus sex was not included in our power calculations. However, we do report findings when including sex in the analyses for each study in the Supplemental Material. Finally, we report results of mediation analyses for current concerns and emotions on choice outcomes in each study in the Supplemental Material.

Study 1

Method

Study 1 examined whether BIS activity affects how much people value their physical attractiveness. To test this, we adapted an investment paradigm (Li, Bailey, Kenrick, & Linsenmeier, 2002) in which participants assign hypothetical dollars to alter traits within themselves. Participants completed this task twice, once with a small budget from which spending should reflect perceived necessities (because the budget size forces trade-offs between trait investment) and once with a larger budget from which spending could incorporate more luxury choices. The use of two budgets allowed us to examine how the motivation to manage appearance is prioritized for pathogen-cued people (see Li et al., 2002).

One hundred sixty participants (73 female, 83 male, 4 unreported; mean age = 34.6 years) completed all study procedures online using the Amazon Mechanical Turk recruitment system in exchange for a nominal payment. After providing informed consent, participants were asked to read a story as a first task. Participants read one of two scenarios to manipulate pathogen threat: a detailed scenario about organizing their home workspace (control condition) or volunteering to work

at a hospital gerontology ward (pathogen-cue condition; White et al., 2013). Following this, participants completed the Positive and Negative Affect Schedule Short Form (Thompson, 2007) along with two additional items ("anxious" and "disgusted") to assess whether the scenario elicited changes in emotional state.

In a second task, participants completed the budget task with the instruction to "design your ideal self, that is, who you want to be today." Participants were given a budget of fictitious dollars that they could spend on 11 traits. Each dollar spent corresponded to a 10th-percentile increase on that particular trait, with a maximum of $10 possible per trait. For example, spending $7 on creativity would mean that one is better than 70% of same-sex peers on that trait. Following Li et al. (2002), participants completed this task twice (order was randomized), once with a budget of $20 (representing the need to spend on necessities) and once with a budget of $60 (representing the freedom to spend on luxury characteristics). The traits participants could purchase were physical attractiveness, creativity, kindness, work ethic, intelligence, romantic ability, sense of humor, virtuousness, social status, nonwork talents/skills, and yearly income. Only one of these traits, physical attractiveness, corresponds with physical appearance.

Following this, we assessed how much participants were currently concerned about four characteristics potentially associated with pathogen threat (physical appearance, physical hygiene, physical fitness, and what others think of you; 1 = *not at all*, 7 = *very much*). Participants then completed the PVD scale and responded to manipulation check and demographic items. They were then debriefed and thanked.

Results

Current concerns. We analyzed the four current concerns by regressing each on pathogen threat, PVD_{GA}, and their interaction. Only one effect was significant—an interaction on concern about physical appearance, b = 0.50, 95% CI = [0.058, 0.950], $t(156) = 2.23$, $p = .027$, sr^2 = .029. For participants cued with pathogen threat, higher levels of chronic germ aversion were associated with a stronger concern about physical appearance, b = 0.62, 95% CI = [0.302, 0.936], $t(156) = 3.86$, $p < .001$, but this was not the case for participants in the control condition, $b = 0.12$, $p = .47$. Further, for participants with high levels of germ aversion, the pathogen prime increased appearance concern relative to the effect of the control prime, $b = 0.67$, 95% CI = [0.025, 1.308], $t(156) = 2.05$, $p = .04$; the relationship for participants with low levels of germ aversion was nonsignificant and in the opposite direction, $b = -0.36$, $p = .27$. The interaction patterns associated with fitness and social concern (but not hygiene) were similar to those for appearance, although not significant (fitness: $b = 0.33$, $p = .16$; social concern: $b = 0.29$, $p = .26$; hygiene: $b = 0.02$, $p = .95$). Thus, on these specific measures of self-relevant evaluation, pathogen threat primarily increased concern with physical appearance.

Trait investment. Following Li et al. (2002), we analyzed the main dependent variables as percentages of total budget spent on each trait (see the Supplemental Material for analyses of actual spending percentiles). Given our predictions, we examined the effect of the manipulations by regressing each trait on scenario condition, centered PVD_{GA}, budget, and their corresponding interactions. A mixed regression using the general linear model repeated measures procedure revealed a significant PVD_{GA} × Budget interaction for spending on physical attractiveness, $F(1, 156) = 5.69$, $p = .018$, $\eta_p^2 = .04$, which was qualified by a Condition × PVD_{GA} × Budget interaction, $F(1, 156) = 10.46$, $p = .001$, $\eta_p^2 = .06$. This indicated that people concerned about pathogens spent a greater percentage of their budget on improving attractiveness when choices involved necessities (i.e., when the budget was small; see Fig. 1a) but not when choices included more freedom to spend on luxury traits (i.e., when the budget was larger; see Fig. 1b). Tests on all other traits showed no significant two- or three-way interactions (all ps > .18).

Given the higher-order interaction for physical attractiveness, we next examined effects within each budget level. At the small (necessity) budget level, regressing attractiveness on scenario condition, centered PVD_{GA}, and their interaction revealed only a significant interaction with condition, $b = 0.05$, 95% CI = [0.012, 0.078], $t(156) = 2.68$, $p = .008$, $sr^2 = .044$. As predicted, simple-effects tests showed that higher levels of chronic germ aversion were associated with more spending on one's own physical attractiveness among participants cued with pathogen threat, $b = 0.03$, 95% CI = [0.002, 0.049], $t(156) = 2.18$, $p = .03$, but not for participants in the control condition (in fact, the pattern for this effect ran in the opposite direction), $p = .11$. Further, for participants with high levels of chronic germ aversion (1 *SD* above the mean), the pathogen prime increased attractiveness spending relative to the effect of the control prime, $b = 0.05$, 95% CI = [0.001, 0.097], $t(156) = 2.03$, $p = .04$; the relationship was in the opposite direction for participants with low levels of germ aversion, $b = -0.04$, 95% CI = [−0.090, 0.005], $t(156) = -1.77$, $p = .08$. Finally, the interaction effect within the small budget level was mediated by appearance concern (see the Supplemental Material).

Analyses at the large (luxury) budget level revealed only a marginal main effect of scenario condition on physical attractiveness, with pathogen threat leading to

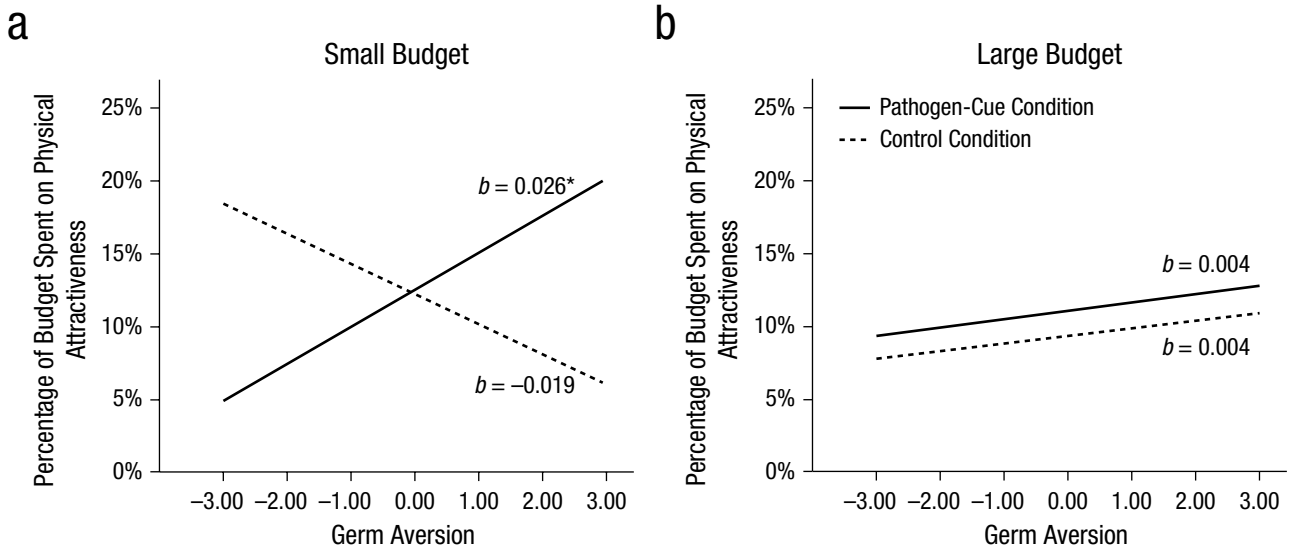

Fig. 1. Results from Study 1: mean percentage of budget spent on enhancing one's own physical attractiveness as a function of score on the Germ Aversion subscale and condition. Results are shown separately for (a) when the budget was small ($20) and represented necessity choices and (b) when the budget was large ($60) and represented greater freedom for luxury choices. The asterisk indicates that the slope was significant (*$p < .05$).

relatively more spending on attractiveness than in the control condition, $b = 0.01$, 95% CI = [–0.002, 0.024], $t(156) = 1.70$, $p = .09$, $sr^2 = .018$. Unlike with the "necessity" budget, no interaction between pathogen threat and PVD_{GA} was found for physical attractiveness at the "luxury" budget level, $p = .96$.

In sum, Study 1 showed that germ-averse people experienced a specific concern about appearance in the face of infectious-disease cues, leading them to invest more in their own physical attractiveness when investment choices represented "necessities" of the self.

Study 2a

Method

Study 2a extended our initial work by assessing participants' interest in purchasing consumer products and engaging in actions that could improve different types of personal characteristics—those related to either physical appearance or health and physical fitness. As in the pilot study, we were open to the possibility that infectious-disease cues could motivate desire for both appearance and fitness traits. We also included the Belief in a Dangerous World (BDW) scale (Altemeyer, 1988) to ensure that pathogen-irrelevant threat perceptions did not also moderate effects of pathogen primes (additional methodological details are included in the Supplemental Material).

Sixty-five undergraduate students (33 female, 32 male; mean age = 18.9 years) participated in a two-condition study in exchange for course credit. Sample size was determined using available resources at the time. Each participant was randomly assigned to read one of two plot summaries from the TV show *MythBusters*, in which the hosts test popular beliefs and legends. One summary (control condition) described the myth, "In one day, many household appliances use more energy than a car burning an entire tank of gasoline," and the other summary (pathogen-cue condition) described the myth, "Many objects that people touch every day are dirtier than a toilet seat." The summaries detailed how the hosts tested the specific myth and how their findings indicated that eight everyday appliances/objects were worse than the focal item in the myth. Following the summary, participants reported the number of these appliances/objects they used daily (maximum = 8) and how recently they interacted with any of the objects in the list (1 = *not very recently*, 7 = *very recently*). Participants then completed several items assessing their current emotional state on scales ranging from 1 to 7 (overall mood, worry, sadness, disgust).

Next, 20 products and behaviors were shown one at a time in random order. Participants judged "How interested/motivated are you in . . ." engaging in each behavior or purchasing each product (1 = *not at all*, 7 = *very*). The items were cosmetic plastic surgery, liposuction, dieting, purchasing cosmetics, eating healthy foods, purchasing diet pills, exercising, working out at a gym, procrastinating less, improving physical coordination, changing appearance, improving typing speed, changing blinking rate, improving social abilities, purchasing tooth-whitening products, purchasing fitness equipment, purchasing a new cell phone, purchasing

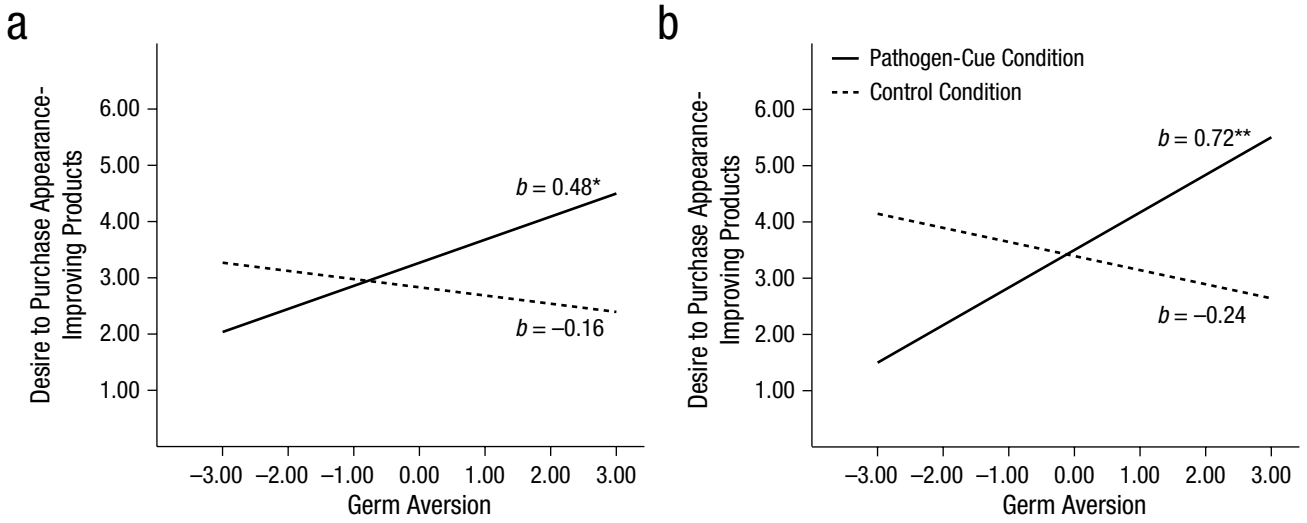

Fig. 2. Results from (a) Study 2a and (b) Study 2b: mean desire to purchase appearance-improving products as a function of score on the Germ Aversion subscale and condition. Asterisks indicate that the slopes were significant (*$p < .05$, **$p < .01$).

new music, purchasing memory-improvement products, and purchasing sleep-improvement products. Participants then completed the PVD and BDW scales along with demographic items before being debriefed and released.

Results

After creating composites for "appearance" solutions, "fitness" solutions, and "other" solutions (see the Supplemental Material for details), we regressed each composite on dummy-coded pathogen-salience condition, centered PVD_{GA}, centered BDW scale, and the PVD_{GA} × Condition interaction. The only significant effect to emerge was a PVD_{GA} × Condition interaction for appearance solutions (see Fig. 2a), $b = 0.64$, 95% CI = [0.062, 1.222], $t(60) = 2.21$, $p = .03$, $sr^2 = .070$. For participants cued with pathogens, higher levels of germ aversion were associated with a stronger desire for appearance-related behaviors and products, $b = 0.48$, 95% CI = [0.017, 0.942], $t(60) = 2.07$, $p = .04$, but this was not the case for participants in the control condition (the pattern for this effect ran in the opposite direction), $b = -0.16$, $p = .36$. Further, for participants with high levels of germ aversion, the pathogen prime increased desire for appearance-related products and behaviors relative to the control prime, $b = 1.02$, 95% CI = [0.250, 1.788], $t(60) = 2.65$, $p = .01$; the relationship was nonsignificant and in the opposite direction for participants with low levels of germ aversion, $b = -0.22$, $p = .57$. No effects of these variables emerged on the other two composites; however, the pattern of results was in same direction for the "other" composite ($b = 0.36$, $p = .32$), but not the "fitness" composite ($b = -0.16$, $p = .66$).

Study 2b

Method

Given the relatively small sample size in Study 2a, we replicated the design with a larger sample in Study 2b. A similar set of products was shown to participants. One hundred seventy-three people (79 female, 94 male, 1 unreported; mean age = 34.6 years) completed all study procedures online using Amazon Mechanical Turk in exchange for a nominal payment. Following exposure to one of the two *MythBusters* plot-summary primes, participants completed several items assessing their current emotional state on scales ranging from 1 to 7 (happiness, worry, sadness, disgust). All other procedures were identical to those in Study 2a, with one exception. Here, participants answered, "How much would you like to purchase and use [this] product?" or "How much would you like to engage in [this] behavior?" for a total of 15 items: cosmetic plastic surgery, liposuction, diet pills, cosmetics/makeup, facial makeover, working out at a gym, eating healthy foods, exercising, fitness equipment, personal activity tracker (like a Fitbit), batteries, light bulbs, trash bags, plastic utensils, and a home computer. Following this, the PVD and BDW scales and demographic items were administered, and participants were debriefed.

Results

As in Study 2a, we created composites for "appearance" solutions, "fitness" solutions, and "other" solutions (see the Supplemental Material for details) and regressed these on dummy-coded pathogen-salience condition, centered PVD_{GA}, centered BDW scale, and the PVD_{GA} ×

Condition interaction. The only significant effect to emerge was a PVD_{GA} × Condition interaction for appearance solutions (see Fig. 2b), $b = 0.97$, 95% CI = [0.227, 1.703], $t(168) = 2.58$, $p = .01$, $sr^2 = .037$. For participants cued with pathogens, higher levels of germ aversion were associated with a stronger desire for appearance-related behaviors and products, $b = 0.72$, 95% CI = [0.247, 1.188], $t(168) = 3.01$, $p = .003$, but this was not the case for participants in the control condition (the pattern for this effect ran in the opposite direction), $b = -0.24$, $p = .40$. Further, for participants with high levels of germ aversion, the pathogen prime increased desire for appearance-related products and behaviors relative to the control prime, $b = 1.21$, 95% CI = [0.166, 2.261], $t(168) = 2.29$, $p = .02$; the relationship was nonsignificant and in the opposite direction for participants with low levels of germ aversion, $b = -0.79$, $p = .15$. No effects of these variables emerged on the other two composites; however, the pattern of results was in the same direction for the "fitness" composite ($b = 0.33$, $p = .36$), but not the "other" composite ($b = -0.29$, $p = .42$). Thus, expanding on our prior findings, these results showed that germ-averse people facing cues to infectious disease were particularly motivated to manage appearance-related characteristics, even when analyses controlled for pathogen-irrelevant threat concerns.

Study 3

Method

Study 3 extended the product-desire effect found in Studies 2a and 2b by contrasting a focus on appearance with a behavior intended to directly manage the threat of infection—hygiene. As in Study 1, we also included measures of concern about characteristics potentially associated with BIS activity to evaluate whether these mediated reported product preferences (see the Supplemental Material for additional detail).

One hundred sixty-four people (86 female, 77 male, 1 unreported; mean age = 35.9 years) completed the study online using Amazon Mechanical Turk in exchange for a nominal payment. The first task replicated the scenario manipulation used in Study 1 as a means of cuing pathogen threat or no threat. Participants then rated themselves on a single item assessing general self-perceived flaws (see the Supplemental Material), and as in Study 1, rated their current concerns about four characteristics potentially associated with BIS activity (physical appearance, physical hygiene, physical fitness, what others think of you; 1 = *not at all*, 7 = *very much*). Note that measurement of these concerns prior to the product-preference items allowed for a more rigorous test of mediation compared with Study 1.

In the second task, participants rated their liking for (−5 = *dislike*, 5 = *like*) and likelihood of purchasing (0 = *not at all*, 10 = *very*) 17 consumer products (chosen based on a pretest reported in the Supplemental Material). These consisted of appearance products (liposuction, cosmetic plastic surgery, diet pills, cosmetics/makeup, blemish cream, facial makeover), hygiene products (soap, shampoo, toothpaste, toilet paper, dental floss, antiseptic hand wipes), and unrelated household products (batteries, light bulbs, aluminum foil, music files/CDs, plastic utensils). Participants then completed the PVD scale and manipulation checks assessing recall for the initial scenario and two self-reported items measuring affective responses to this scenario (1 = *very negative* and *very calm*, 7 = *very positive* and *very anxious*). Finally, participants answered demographic items and a suspicion probe.

Results

Three people were removed from the analysis because they accurately suspected our hypothesis, leaving 161 participants.

Current concerns. The four current concerns (physical appearance, physical hygiene, physical fitness, what others think of you) were regressed on the two predictors and their interaction. A significant Condition × Germ Aversion interaction emerged for concern about physical appearance, $b = 0.55$, 95% CI = [0.104, 1.002], $t(157) = 2.43$, $p = .016$, $sr^2 = .035$. For participants experimentally cued with pathogens, higher levels of chronic germ aversion were associated with a stronger concern about physical appearance, $b = 0.55$, 95% CI = [0.249, 0.852], $t(157) = 3.61$, $p < .001$, but this was not the case for participants in the control condition, $b = -0.002$, $p = .99$. Further, for participants with high levels of germ aversion, the pathogen prime increased appearance concerns relative to effect of the control prime, $b = 0.82$, 95% CI = [0.179, 1.461], $t(157) = 2.53$, $p = .013$; the relationship was nonsignificant and in the opposite direction for participants with low levels of germ aversion, $b = -0.30$, $p = .36$. In addition, a marginally significant interaction on hygiene concern suggested that pathogen cues elicited more concern about hygiene in people highly averse to germs, $b = 0.40$, 95% CI = [−0.062, 0.858], $t(157) = 1.71$, $p = .09$, $sr^2 = .018$. The interaction effects for fitness ($b = 0.24$, $p = .26$) and social concern ($b = 0.04$, $p = .87$) were not significant.

Product desire. The three product composites (appearance, hygiene, unrelated) were separately regressed on dummy-coded scenario condition, centered PVD_{GA}, and their interaction. A Condition × Germ Aversion interaction was observed only on desire for appearance products

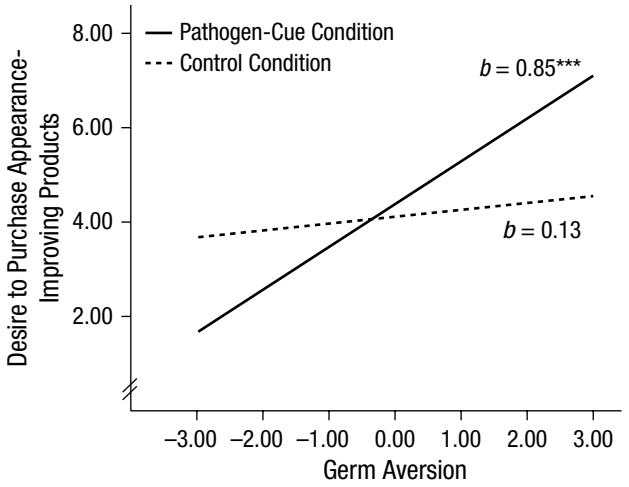

Fig. 3. Results from Study 3: mean desire to purchase appearance-improving products as a function of score on the Germ Aversion subscale and condition. Asterisks indicate that the slope was significant (***$p < .001$).

(see Fig. 3), $b = 0.72$, 95% CI = [0.053, 1.390], $t(157) = 2.13$, $p = .035$, $sr^2 = .026$. For participants cued with pathogens, higher levels of germ aversion were associated with a stronger desire for appearance products, $b = 0.85$, 95% CI = [0.402, 1.299], $t(157) = 3.74$, $p < .001$, but this was not the case for participants in the control condition, $b = 0.13$, $p = .61$. Further, for participants with high levels of germ aversion, the pathogen prime increased desire for appearance products relative to effect of the control prime, $b = 1.25$, 95% CI = [0.041, 2.206], $t(157) = 2.59$, $p = .011$; the relationship was nonsignificant and in the opposite direction for participants with low levels of germ aversion, $b = -0.21$, $p = .66$. No effects of these variables emerged on the other two composites; however, the pattern of results was in the same direction for the "hygiene" composite ($b = 0.21$, $p = .35$) and the "household" composite ($b = 0.25$, $p = .29$). Thus, as in earlier studies, germ-averse people primed by situational pathogen cues were especially concerned about their appearance and showed a greater desire to purchase products associated with appearance improvements.

Study 4

Method

The focus of our approach thus far was on the appearance-related effects of BIS activity, although Studies 2b and 3 indicated directional or marginal support for possible hygiene and fitness effects. Study 4 used a larger sample to investigate whether this activity elevates the motivation for people to seek out not only appearance-improving products, but also products that may improve bodily health, namely, hygienic and fitness products. These studies were conducted in response to review comments on an earlier submission and were preregistered; they included a sample large enough to achieve 95% power given the effect sizes across studies (see the Supplemental Material for details).

Seven hundred ninety-five people (460 female, 327 male, 8 unreported; mean age = 38.0) completed the full study online using Amazon Mechanical Turk in exchange for a nominal payment. The first task replicated the scenario manipulation used in Study 1 as a means of cuing pathogen threat or no threat. As in the earlier studies, participants then rated their current concerns about characteristics potentially associated with BIS activity (physical appearance, physical hygiene, physical fitness, what others think of you; 1 = *not at all*, 7 = *very much*) and one new item representing a likely irrelevant characteristic (household products).

In the second task, participants rated their liking for (−5 = *dislike*, 5 = *like*) and interest in purchasing, using, or engaging in (−5 = *extremely disinterested*, 5 = *extremely interested*) 28 consumer products or activities (chosen on the basis of a pretest reported in the Supplemental Material). These items related to appearance (liposuction, cosmetic plastic surgery, diet pills, cosmetics/makeup, blemish cream, facial makeover, hair dye), hygiene (shampoo, toothbrush, mouthwash, dental floss, hand sanitizer, deodorant, razors), physical fitness (fitness equipment, working out at a gym, cardio machine, exercise, lifting weights, treadmill, exercise mat), and the household (batteries, light bulbs, aluminum foil, plates, extension cord, lamp, clock). Participants then completed the PVD scale and manipulation checks assessing recall for the initial scenario and three self-reported items measuring affective responses to this scenario (1 = *very negative*, *very calm*, *not at all disgusted*; 7 = *very positive*, *very anxious*, *very disgusted*). Participants were also asked whether they had previously taken a similar online study that used the same initial scenarios. Finally, participants answered demographic items and a suspicion probe.

Results

Following our preregistration criteria, we removed 35 participants for failing the manipulation check, taking a study with the same materials multiple times, or taking longer than 5 standard deviations above the mean in completion time. In addition, we decided to exclude 5 participants for accurately suspecting our hypotheses and 5 participants for failing an initial instruction check. This left 750 participants for the analyses.

Current concerns. The five current concerns (physical appearance, physical hygiene, physical fitness, what others think of you, household products) were regressed on prime condition, germ aversion, and their interaction. In contrast with prior studies, one marginal main effect of prime condition emerged, for physical fitness concerns, $b = -0.17$, 95% CI = [−0.366, 0.094], $t(745) = -1.70$, $p = .09$, $sr^2 = .004$, with participants in the control condition ($M = 5.24$, $SD = 1.35$) showing greater fitness concern than participants in the pathogen condition ($M = 5.05$, $SD = 1.42$), but no other main effects of condition or interactions were significant (all ps > .30). However, the main effect of germ aversion was significant for all outcomes (all ps < .02, $R^2 \geq .008$). For all outcomes, greater germ aversion was associated with more concern.

Product desire. A mixed regression using the general linear model repeated measures procedure for the four product composites (appearance, hygiene, fitness, household) predicted by dummy-coded scenario condition, centered PVD_{GA}, and their interaction revealed no main effect of condition or, contrary to predictions, a Germ Aversion × Condition interaction (ps > .34). However, main effects of germ aversion, $F(1, 746) = 38.09$, $p < .001$, $\eta_p^2 = .05$, and product type, $F(3, 744) = 717.73$, $p < .001$, $\eta_p^2 = .74$, emerged along with a Product Type × Germ Aversion interaction, $F(3, 744) = 8.63$, $p < .001$, $\eta_p^2 = .03$. To better specify the results of the latter effect, we first examined contrasts between levels of product type. The effect of germ aversion on product desire was significantly different between appearance and household products, $F(1, 746) = 8.58$, $p = .004$, $\eta_p^2 = .01$, and between hygiene and household products, $F(1, 746) = 24.23$, $p < .001$, $\eta_p^2 = .03$. It was also marginally different between fitness and household products, $F(1, 746) = 3.04$, $p = .082$, $\eta_p^2 = .004$. The effect of germ aversion did not differ between appearance and hygiene ($p = .61$), appearance and fitness ($p = .26$), or fitness and hygiene ($p = .41$).

We next regressed each product composite on the predictors separately using the MODPROBE tool (Hayes & Matthes, 2009). For both appearance and hygiene composites, the main effect of germ aversion was significant—appearance: $b = 0.38$, 95% CI = [0.172, 0.593], $t(746) = 3.57$, $p < .001$, $sr^2 = .017$; hygiene: $b = 0.29$, 95% CI = [0.155, 0.424], $t(746) = 4.22$, $p < .001$, $sr^2 = .023$. As in earlier studies, germ aversion predicted product desire in the pathogen condition (appearance: $b = 0.30$, $p = .001$; hygiene: $b = 0.32$, $p < .001$); in contrast with these previous studies, it also predicted product desire in the control condition (appearance: $b = 0.38$, $p < .001$; hygiene: $b = 0.29$, $p < .001$). No effects were found for prime condition or the interaction (ps > .57). For the fitness composite, a main effect of germ aversion, $b = 0.35$, 95% CI = [0.129, 0.564], $t(746) = 3.13$, $p = .002$, $sr^2 = .013$, and a marginal effect of condition (showing relatively less interest in the pathogen-cue condition), $b = -0.29$, 95% CI = [−0.614, 0.030], $t(746) = -1.78$, $p = .08$, $sr^2 = .004$, emerged. No effects for the household composite emerged (all ps > .13), suggesting that disease concerns were irrelevant for this type of desire. These results were inconsistent with our prediction of an interaction effect between germ aversion and experimental condition. Here, germ aversion predicted product desire not only in the pathogen-cue condition, but also in the control condition. Nevertheless, the main effects of germ aversion do suggest that infectious-disease concerns relate to self-image.

Study 5

Method

Given our primary focus in this investigation, Studies 5a and 5b concentrated on the influence of BIS activity on perceived appearance imperfections using a measure specifically designed to assess satisfaction with appearance rather than the more indirect inference required for interpreting desire for appearance-related products. These studies also examined whether an unrelated threat will trigger concerns about one's appearance, particularly in people especially sensitive to that specific threat (as might be predicted by alternative, domain-general threat perspectives). To address this issue, we cued participants with either pathogen danger or the danger of personal property loss, and they completed relevant individual-difference measures (i.e., PVD and BDW). As with Study 4, these studies were conducted in response to reviewer comments on an earlier submission and were preregistered; they included a sample large enough to achieve 95% power given the effect sizes in Studies 1 through 3 (see the Supplemental Material for details). Because of an author oversight, the study was originally run without the BDW measure (Study 5a), and so it was run a second time with it (Study 5b). We present results from both studies.

Three hundred eleven participants (162 female, 148 male, 1 unreported; mean age = 35.9 years) completed all measures in Study 5a, and 297 participants (160 female, 137 male; mean age = 37.0 years) completed all measures in Study 5b, using Amazon Mechanical Turk in exchange for a nominal payment. After providing informed consent, participants read either the hospital scenario used in Study 1 (pathogen-threat condition) or a new scenario created to elicit a similar degree of threat unrelated to the dangers of infectious disease (property-crime condition; see the Supplemental Material for pretest details on the scenarios). To measure appearance concern, we asked participants to

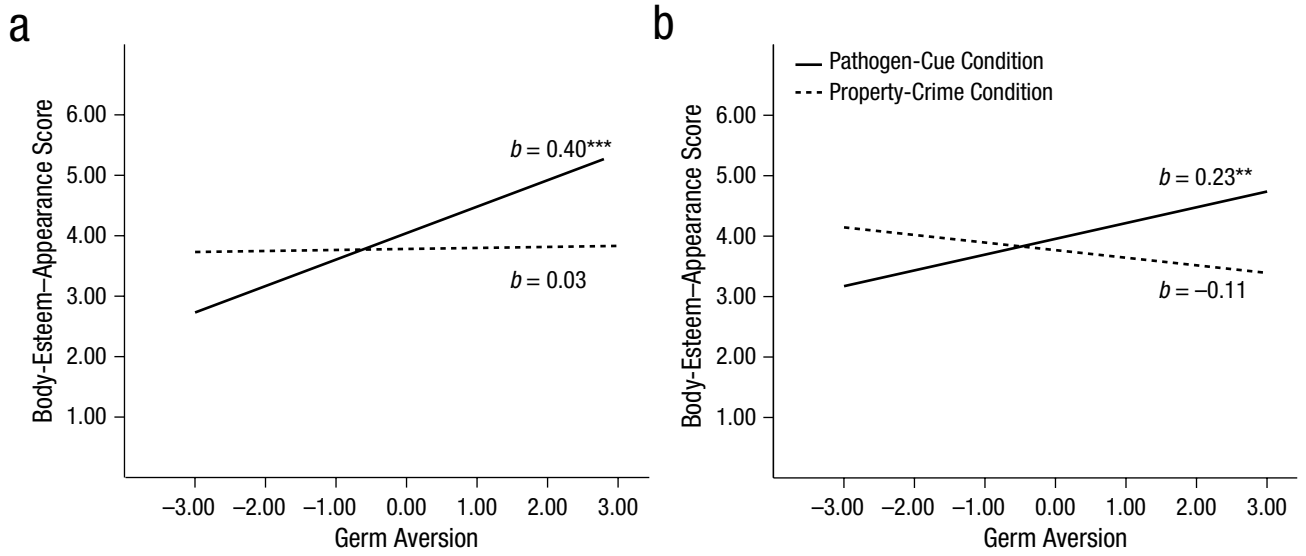

Fig. 4. Results from (a) Study 5a and (b) Study 5b: mean concern about personal physical appearance as a function of score on the Germ Aversion subscale and condition. Concern about physical appearance was assessed using a modified version of the Appearance subscale of the Body-Esteem Scale for Adolescents and Adults (Mendelson, Mendelson, & White, 2001). Asterisks indicate that the slopes were significant (**$p < .01$, ***$p < .001$).

complete the Appearance subscale of the Body-Esteem Scale for Adolescents and Adults, which was modified to refer to self-evaluations in the present moment (rather than the chronic framing used in the original scale; Mendelson, Mendelson, & White, 2001). Several current-emotion items were then given to confirm reactions to the scenarios: general mood (−3 = *very negative*, 3 = *very positive*) as well as anxiety, worry, vulnerability, fear, physical disgust, moral disgust, grossed out, and anger (1 = *not at all*, 7 = *very much*). Next, the PVD and BDW scales were presented in randomized order. Finally, participants completed demographic items and were debriefed and paid.

Results

Study 5a. Four participants repeated the study multiple times, and so we removed their second set of data, leaving a total of 307 participants. Results for the current-emotion items showed that the pathogen scenario produced higher levels of physical disgust, while the crime scenario produced higher levels of negativity unrelated to infectious disease (see the Supplemental Material for details). A composite for the Body-Esteem–Appearance subscale was created by reverse-scoring positive items, producing a composite with higher values indicating insecurity about one's appearance (Cronbach's α = .93). We regressed this composite on dummy-coded condition, a centered composite for PVD_{GA}, and their interaction. This analysis revealed only a Condition × PVD_{GA} interaction (see Fig. 4a), $b = 0.37$, 95% CI = [0.074, 0.668], $t(303) = 2.46$, $p = .015$, $sr^2 = .019$. For participants cued with pathogens, higher levels of germ aversion were associated with stronger insecurity about physical appearance, $b = 0.40$, 95% CI = [0.198, 0.603], $t(303) = 3.89$, $p < .001$, but this was not the case for participants in the crime condition, $b = 0.03$, $p = .79$. In addition, for participants high in germ aversion, the pathogen scenario produced greater appearance insecurity than the crime scenario, $b = 0.64$, 95% CI = [0.195, 1.080], $t(303) = 2.84$, $p = .005$; the relationship was nonsignificant and in the opposite direction for participants with low levels of germ aversion, $b = -0.15$, $p = .52$.

Study 5b. Three participants repeated the study multiple times, and so we removed their second set of data, and 2 participants were removed for taking longer than 5 standard deviations from the mean to complete the study (see preregistration exclusion criteria), leaving a total of 292 participants. Results for the current-emotion items are reported in the Supplemental Material. We regressed the Body-Esteem–Appearance composite (Cronbach's α = .89) on dummy-coded condition, a centered composite for PVD_{GA}, a centered composite for BDW, and the Condition × PVD_{GA} and Condition × BDW interactions. This analysis revealed only a significant Condition × PVD_{GA} interaction (see Fig. 4b), $b = 0.34$, 95% CI = [0.066, 0.621], $t(285) = 2.44$, $p = .016$, $sr^2 = .020$. No effects of BDW emerged ($ps > .60$). Simple-effects tests of the significant interaction were conducted, including the BDW and Condition × BDW terms for consistency. For participants cued with pathogens, higher levels of germ aversion were

associated with stronger insecurity about physical appearance, $b = 0.23$, 95% CI = [0.055, 0.409], $t(285) = 2.58$, $p = .01$, but this was not the case for participants in the control condition (the effect ran in the opposite direction), $b = -0.11$, $p = .30$. In addition, for participants high in germ aversion, the pathogen scenario produced greater appearance insecurity than the crime scenario, $b = 0.49$, 95% CI = [0.077, 0.905], $t(285) = 2.33$, $p = .02$, the relationship was nonsignificant and in the opposite direction for participants with low levels of germ aversion, $b = -0.27$, $p = .20$.

Internal Meta-Analyses

In six of the seven studies presented here, interactions between chronic germ aversion and experimental condition emerged on concerns about—and motivations to improve—physical appearance. A look at the simple effects also paints a clear picture: In all pathogen-threat conditions, germ aversion predicted interest in and concern about appearance. This association was seemingly weaker in the control conditions, with a significant correlation between the variables in only one of seven studies. Moving beyond these surface summaries, we quantified overall effect sizes by conducting multiple meta-analyses of the seven studies.

We conducted five random-effects meta-analyses—one for the interaction between prime type and PVD_{GA}, and one for each of the four possible simple effects within this interaction. For the interactions, R^2 change scores were converted to r scores. For the simple effects, we examined prime separately for participants above and below the median of PVD_{GA} as well as PVD_{GA} separately for participants in the pathogen-cue and control conditions. Effect sizes were analyzed using Comprehensive Meta-Analysis software (2017; specific values used are reported in the Supplemental Material, along with an additional meta-analysis for the main effect of prime). We report all effect sizes as rs. We also report τ, which reflects the between-studies standard deviation of effect sizes (Borenstein, Hedges, Higgins, & Rothstein, 2010).

The meta-analyzed effect size of the Prime Condition × PVD_{GA} interaction was $r = .142$, 95% CI = [.073, .210], $\tau = 0.065$. Further, the simple-effect meta-analyses suggested that PVD_{GA} was related to appearance concerns in the pathogen-cue condition, $r = .267$, 95% CI = [.188, .342], $\tau = 0.061$, but not in the control condition, $r = -.010$, 95% CI = [−.118, .099], $\tau = .108$. Finally, the meta-analyses suggested that pathogen primes increased appearance concerns for individuals above the median PVD_{GA}, $r = .169$, 95% CI = [.064, .270], $\tau = 0.11$, but had no effect on participants below the median PVD_{GA}, $r = -.026$, 95% CI = [−.088, .037], $\tau = 0.00$.

Results of these meta-analyses indicate a Person × Situation interaction, with pathogen cues increasing appearance concerns for those individuals especially averse to such cues. The simple-effects tests revealed that germ aversion was associated with appearance concern only when pathogen threat was situationally induced and that pathogen threat most strongly affected people chronically high in germ aversion—those who are expected to be especially sensitive to infectious-disease cues (for further discussion about the issue of main effects vs. interactions in the BIS literature, see Tybur et al., 2014). We also note that interaction effect sizes were variable across studies. Variation in the priming effects was more pronounced for participants with high germ aversion compared with participants with low germ aversion, and variation in the PVD_{GA} effects was more pronounced in the control conditions than in the pathogen-cue conditions. The existence of variability is unsurprising, given alterations in aspects of the primes, dependent measures, and sample characteristics across studies. Though we hesitate to make strong conclusions regarding this differential variation, it may have arisen from distinctions in study characteristics, unequal measurement error, or perhaps unidentified boundary conditions.

General Discussion

Does the threat of infectious disease affect how people see themselves? Here, we showed that sensitivity to this threat alters intrapersonal perceptions, suggesting that self-image can be an outlet for behavioral immune responses. Across studies, germ aversion was associated with increased concern about physical appearance and a desire for appearance-improving products and behaviors in all seven conditions featuring salient pathogen cues, whereas this was true in only one control condition (Study 4). Other physically relevant outcomes, such as hygiene and fitness desires, were more inconsistently associated with these predictors. This does not imply that chronic or situational pathogen concerns necessarily exert a stronger influence on management of one's appearance than management of one's hygiene or fitness. When faced with a context indicating a high probability of infection (e.g., shaking hands with someone clearly suffering from the flu), people are likely to prioritize washing their hands over combing their hair, for example. Indeed, results from Study 4 indicate that chronic germ concern predicts desire for hygiene and fitness products, though not desire for everyday household products. Nevertheless, these findings do suggest that physical-appearance characteristics represent important inputs for psychological defense mechanisms against infectious disease.

The self-directed nature of this research helps address researchers' recent calls for the mapping of "aspects of our psychology that function to neutralize pathogens, but which are not part of the BIS, as currently defined" (Tybur et al., 2014, p. 280). This work also helps to ground research on infectious disease within the broader literatures on self-evaluation and self-image. Further, it suggests that contexts marked by heightened pathogen threat may be accompanied by an increased likelihood of problematic cognitions associated with appearance, including poorer body image, self-objectification, and certain clinical disorders.

Given the BIS-appearance association, what might be its underlying function? Earlier, we introduced three potential functions: management of health, social standing, or mating opportunities. A health-management function is weakly consistent with the current data, which demonstrated effects of threat on hygiene concern in Studies 3 and 4, but not in Study 1 (support for the health-related attribute of physical fitness was even more inconsistent). A social-standing function did not receive much support, as only one study found an association with pathogen threat through chronic germ aversion in Study 4. Prior studies do indicate that pathogen prevalence predicts adherence to social norms (e.g., Murray, Trudeau, & Schaller, 2011), and so it may be that measures other than self-report would better speak to desire for social standing. Finally, improvements in physical appearance are clearly relevant for romantic success. Whether this function underlies the shifts in appearance concern found here remains to be tested in mating-relevant contexts. We discuss these functions in more detail in the Supplemental Material.

Additional Directions and Limitations

Our studies indexed concern about physical appearance using a variety of methods, from measurement of trait investments to product preferences. Future work could use behavioral methods to assess this concern, such as by recording the degree to which pathogen-threatened individuals alter their appearance in anticipation of a social interaction. Similarly, consumer sales data could provide insight into actual purchase decisions. On the basis of our findings, one prediction is that change in purchasing patterns for appearance-related products occurring during periods of high disease salience (e.g., flu season, media coverage about epidemics) would be driven by highly germ-averse consumers.

Although our theoretical framework led us to concentrate on the link between behavioral immune activity and appearance, we did not assess connections between appearance and actual infection vulnerability. Self-perceived imperfections may index developmental instabilities indicating lowered resistance to pathogen encounters. Because other people carry pathogens, biases that encourage limiting social contact could reduce the potential for infection. This bias would be most useful for those at greater risk of infection, such as recently ill and immunocompromised people. However, the fact that chronic perceived infectability did not consistently relate to appearance concern (see the Supplemental Material) cautions against an interpretation that situational pathogen threats prompt explicit perceptions of internal health vulnerability.

Conclusion

Evaluations of the self are dynamic and context-specific. Here, we highlight a set of important but previously overlooked factors that can negatively impact these evaluations—those involving the salience of infectious disease. Germ-averse people were more concerned about their physical appearance and desired products and behaviors serving to mitigate these concerns, primarily in the context of pathogen cues. Consideration of pathogen salience as an influence on such processes may afford new insights into both theoretical accounts of self-image and practical approaches to managing the psychological outcomes resulting from negative self-views.

Action Editor

Steven W. Gangestad served as action editor for this article.

Author Contributions

J. M. Ackerman and C. R. Mortensen developed the study concept. J. M. Ackerman supervised study design, data collection, and data analyses. Study design and data interpretation were done in collaboration with J. M. Tybur and C. R. Mortensen. All authors contributed to the development of the manuscript. All authors approved the final version of the manuscript for submission.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

Additional supporting information can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797617733829

Open Practices

All data and materials have been made publicly available via the Open Science Framework and can be accessed at https://osf.io/tsyrj. The hypotheses, data collection and analysis plans, and exclusion criteria for Studies 4, 5a, and 5b were preregistered at https://osf.io/9xqpw/ and https://osf.io/zvhb8/. The complete Open Practices Disclosure for this article can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797617733829. This article has received badges for Open Data, Open Materials, and Preregistration. More information about the Open Practices badges can be found at http://www.psychologicalscience.org/publications/badges.

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